CLAIMS

1. A liquid crystal optical element for use in an optical apparatus having a light source, an objective lens for focusing a light beam from said light source onto a medium, and a tracking means for moving said objective lens to correct an axis displacement of said objective lens, said liquid crystal optical element comprising:

a first transparent substrate;

a second transparent substrate;

a liquid crystal sealed between said first and second transparent substrates; and

an electrode pattern as a region for advancing or delaying the phase of said light beam and correcting wavefront aberration, wherein

said region is formed smaller than the field of view of said objective lens so that said region substantially stays within the field of view of said objective lens regardless of the tracking motion of said tracking means.

2. The liquid crystal optical element according to claim 1, wherein said electrode pattern is a coma aberration correcting electrode pattern, and

said region has a first region for advancing the phase of said light beam and a second region for delaying the phase of said light beam.

3. The liquid crystal optical element according to claim 2, wherein said electrode pattern has a third region that does not substantially change the phase of said light beam.

4. The liquid crystal optical element according to claim 2, wherein said region has only one said first region and only one said second region.

5. The liquid crystal optical element according to claim 2, wherein said region has two of said first regions and two of said second regions.

6. The liquid crystal optical element according to

claim 2, wherein said first and second regions together are formed smaller than, and 50 μm to 300 μm inwardly of, the field of view of said objective lens when said tracking means is in a non-operating condition.

7. The liquid crystal optical element according to claim 2, wherein said first and second regions together are formed smaller than, and inwardly of, the field of view of said objective lens so that residual coma aberration of said light beam after said aberration correction is kept within $\lambda/4$, where λ is the wavelength of said light beam, when said tracking means is in a non-operating condition.

8. The liquid crystal optical element according to claim 2, wherein said first and second regions together are formed smaller than, and inwardly of, the field of view of said objective lens so that residual coma aberration of said light beam after said aberration correction is kept within $\lambda/14$, where λ is the wavelength of said light beam, when said tracking means is in a non-operating condition.

9. The liquid crystal optical element according to claim 2, wherein said first and second regions together are formed smaller than and inwardly of the field of view of said objective lens so that residual coma aberration of said light beam after said aberration correction is kept within 33 mλ, where λ is the wavelength of said light beam, when said tracking means is in a non-operating condition.

10. The liquid crystal optical element according to claim 1, wherein said electrode pattern is a spherical aberration correcting electrode pattern, and

said region has a plurality of subregions for advancing or delaying the phase of said light beam.

11. The liquid crystal optical element according to claim 10, wherein said plurality of subregions are formed smaller than, and 50 μm to 300 μm inwardly of, the field

of view of said objective lens when said tracking means is in a non-operating condition.

12. The liquid crystal optical element according to claim 10, wherein said plurality of subregions are formed smaller than, and inwardly of, the field of view of said objective lens so that residual coma aberration of said light beam after said aberration correction is kept within $\lambda/4$, where λ is the wavelength of said light beam, when said tracking means is in a non-operating condition.

13. The liquid crystal optical element according to claim 10, wherein said plurality of subregions are formed smaller than, and inwardly of, the field of view of said objective lens so that residual coma aberration of said light beam after said aberration correction is kept within $\lambda/14$, where λ is the wavelength of said light beam, when said tracking means is in a non-operating condition.

14. The liquid crystal optical element according to claim 10, wherein said plurality of subregions are formed smaller than, and inwardly of, the field of view of said objective lens so that residual coma aberration of said light beam after said aberration correction is kept within 33 mλ, where λ is the wavelength of said light beam, when said tracking means is in a non-operating condition.

15. The liquid crystal optical element according to claim 2, wherein said electrode pattern includes a coma aberration correcting electrode pattern formed on either one of said first and second transparent substrates and a spherical aberration correcting electrode pattern formed on the other one of said first and second transparent substrates.

16. The liquid crystal optical element according to claim 15, wherein said region for said coma aberration correcting electrode pattern has a first region for advancing the phase of said light beam and a second

region for delaying the phase of said light beam.

17. The liquid crystal optical element according to claim 16, wherein said coma aberration correcting electrode pattern has a third region that does not substantially change the phase of said light beam.

18. The liquid crystal optical element according to claim 16, wherein said first and second regions together are formed smaller than, and 80 μm to 500 μm inwardly of, the field of view of said objective lens when said tracking means is in a non-operating condition.

19. The liquid crystal optical element according to claim 16, wherein said first and second regions together are formed smaller than, and inwardly of, the field of view of said objective lens so that residual coma aberration of said light beam after said aberration correction is kept within λ/4, where λ is the wavelength of said light beam, when said tracking means is in a non-operating condition.

20. The liquid crystal optical element according to claim 16, wherein said first and second regions together are formed smaller than, and inwardly of, the field of view of said objective lens so that residual coma aberration of said light beam after said aberration correction is kept within λ/14, where λ is the wavelength of said light beam, when said tracking means is in a non-operating condition.

21. The liquid crystal optical element according to claim 16, wherein said first and second regions together are formed smaller than, and inwardly of, the field of view of said objective lens so that residual coma aberration of said light beam after said aberration correction is kept within 33 λm, where λ is the wavelength of said light beam, when said tracking means is in a non-operating condition.

22. The liquid crystal optical element according to claim 15, wherein said region for said spherical

aberration correcting electrode pattern has a plurality of subregions for advancing or delaying the phase of said light beam.

23. The liquid crystal optical element according to claim 22, wherein said plurality of subregions are formed smaller than, and 70 μm to 400 μm inwardly of, the field of view of said objective lens when said tracking means is in a non-operating condition.

24. The liquid crystal optical element according to claim 22, wherein said plurality of subregions are formed smaller than, and inwardly of, the field of view of said objective lens so that residual coma aberration of said light beam after said aberration correction is kept within λ/4, where λ is the wavelength of said light beam, when said tracking means is in a non-operating condition.

25. The liquid crystal optical element according to claim 22, wherein said plurality of subregions are formed smaller than, and inwardly of, the field of view of said objective lens so that residual coma aberration of said light beam after said aberration correction is kept within λ/14, where λ is the wavelength of said light beam, when said tracking means is in a non-operating condition.

26. The liquid crystal optical element according to claim 22, wherein said plurality of subregions are formed smaller than, and inwardly of, the field of view of said objective lens so that residual coma aberration of said light beam after said aberration correction is kept within 33 mλ, where λ is the wavelength of said light beam, when said tracking means is in a non-operating condition.

27. The liquid crystal optical element according to claim 22, wherein said coma aberration correcting electrode pattern is used for a DVD.

28. The liquid crystal optical element according to claim 22, wherein said spherical aberration correcting

electrode pattern is used for a CD.

29. The liquid crystal optical element according to claim 22, wherein said objective lens is an objective lens for said DVD.

30. An optical apparatus for focusing a light beam onto a medium, comprising:

a light source;

an objective lens for focusing the light beam from said light source onto said recording medium;

a tracking means for moving said objective lens to correct an axis displacement of said objective lens; and

a liquid crystal optical element mounted separately from said objective lens, wherein said liquid crystal optical element includes:

a first transparent substrate;

a second transparent substrate;

a liquid crystal sealed between said first and second transparent substrates; and

an electrode pattern as a region for advancing or delaying the phase of said light beam and thereby correcting wavefront aberration, wherein said region is formed smaller than the field of view of said objective lens so that said region substantially stays within the field of view of said objective lens regardless of tracking motion of said tracking means.

31. The optical apparatus according to claim 30, wherein said electrode pattern is a coma aberration correcting electrode pattern, and

said region has a first region for advancing the phase of said light beam and a second region for delaying the phase of said light beam.

32. The optical apparatus according to claim 31, wherein said electrode pattern has a third region that does not substantially change the phase of said light beam.

33. The optical apparatus according to claim 31,

wherein said region has only one said first region and only one said second region.

34. The optical apparatus according to claim 31, wherein said region has two of said first regions and two of said second regions.

35. The optical apparatus according to claim 31, wherein said first and second regions together are formed smaller than, and 50 μm to 300 μm inwardly of, the field of view of said objective lens when said tracking means is in a non-operating condition.

36. The optical apparatus according to claim 31, wherein said first and second regions together are formed smaller than, and inwardly of, the field of view of said objective lens so that residual coma aberration of said light beam after said aberration correction is kept within $\lambda/4$, where λ is the wavelength of said light beam, when said tracking means is in a non-operating condition.

37. The optical apparatus according to claim 31, wherein said first and second regions together are formed smaller than, and inwardly of, the field of view of said objective lens so that residual coma aberration of said light beam after said aberration correction is kept within $\lambda/14$, where λ is the wavelength of said light beam, when said tracking means is in a non-operating condition.

38. The optical apparatus according to claim 31, wherein said first and second regions together are formed smaller than, and inwardly of, the field of view of said objective lens so that residual coma aberration of said light beam after said aberration correction is kept within 33 mλ, where λ is the wavelength of said light beam, when said tracking means is in a non-operating condition.

39. The optical apparatus according to claim 30, wherein said electrode pattern is a spherical aberration correcting electrode pattern, and

said region has a plurality of subregions for advancing or delaying the phase of said light beam.

40. The optical apparatus according to claim 39, wherein said plurality of subregions are formed smaller than, and 50 μm to 300 μm inwardly of, the field of view of said objective lens when said tracking means is in a non-operating condition.

41. The optical apparatus according to claim 39, wherein said plurality of subregions are formed only in an inside region smaller than an effective diameter of said objective lens so that residual coma aberration of said light beam after said aberration correction is kept within $\lambda/4$, where λ is the wavelength of said light beam, when said tracking means is in a non-operating condition.

42. The optical apparatus according to claim 39, wherein said plurality of subregions are formed smaller than, and inwardly of, the field of view of said objective lens so that residual coma aberration of said light beam after said aberration correction is kept within $\lambda/14$, where λ is the wavelength of said light beam, when said tracking means is in a non-operating condition.

43. The optical apparatus according to claim 39, wherein said plurality of subregions are formed smaller than, and inwardly of, the field of view of said objective lens so that residual coma aberration of said light beam after said aberration correction is kept within 33 mλ, where λ is the wavelength of said light beam, when said tracking means is in a non-operating condition.

44. The optical apparatus according to claim 39, further comprising a voltage applying means for applying a voltage to said spherical aberration correcting electrode pattern according to generated spherical aberration.

45. The optical apparatus according to claim 39,

wherein said recording medium has a plurality of track surfaces, and

said optical apparatus further comprises a voltage applying means for activating said spherical aberration correcting electrode pattern according to said plurality of track surfaces.

46. The optical apparatus according to claim 30, wherein said electrode pattern includes a coma aberration correcting electrode pattern formed on either one of said first and second transparent substrates and a spherical aberration correcting electrode pattern formed on the other one of said first and second transparent substrates.

47. The optical apparatus according to claim 46, wherein said region for said coma aberration correcting electrode pattern has a first region for advancing the phase of said light beam and a second region for delaying the phase of said light beam.

48. The optical apparatus according to claim 46, wherein said coma aberration correcting electrode pattern has a third region that does not substantially change the phase of said light beam.

49. The optical apparatus according to claim 46, wherein said first and second regions together are formed smaller than, and 80 μm to 500 μm inwardly of, the field of view of said objective lens when said tracking means is in a non-operating condition.

50. The optical apparatus according to claim 46, wherein said first and second regions together are formed smaller than, and inwardly of, the field of view of said objective lens so that residual coma aberration of said light beam after said aberration correction is kept within $\lambda/4$, where λ is the wavelength of said light beam, when said tracking means is in a non-operating condition.

51. The optical apparatus according to claim 46, wherein said first and second regions together are formed

smaller than, and inwardly of, the field of view of said objective lens so that residual coma aberration of said light beam after said aberration correction is kept within $\lambda/14$, where λ is the wavelength of said light beam, when said tracking means is in a non-operating condition.

52. The optical apparatus according to claim 46, wherein said first and second regions together are formed smaller than, and inwardly of, the field of view of said objective lens so that residual coma aberration of said light beam after said aberration correction is kept within 33 mλ, where λ is the wavelength of said light beam, when said tracking means is in a non-operating condition.

53. The optical apparatus according to claim 46, wherein said region for said spherical aberration correcting electrode pattern has a plurality of subregions for advancing or delaying the phase of said light beam.

54. The optical apparatus according to claim 53, wherein said plurality of subregions are formed smaller than, and 70 μm to 400 μm inwardly of, the field of view of said objective lens when said tracking means is in a non-operating condition.

55. The optical apparatus according to claim 53, wherein said plurality of subregions are formed smaller than, and inwardly of, the field of view of said objective lens so that residual coma aberration of said light beam after said aberration correction is kept within $\lambda/4$, where λ is the wavelength of said light beam, when said tracking means is in a non-operating condition.

56. The optical apparatus according to claim 53, wherein said plurality of subregions are formed smaller than, and inwardly of, the field of view of said objective lens so that residual coma aberration of said light beam after said aberration correction is kept

within $\lambda/14$, where λ is the wavelength of said light beam, when said tracking means is in a non-operating condition.

57. The optical apparatus according to claim 53, wherein said plurality of subregions are formed smaller than, and inwardly of, the field of view of said objective lens so that residual coma aberration of said light beam after said aberration correction is kept within 33 mλ, where λ is the wavelength of said light beam, when said tracking means is in a non-operating condition.

58. The optical apparatus according to claim 46, further comprising a switching means for switching operation between said coma aberration correcting electrode pattern and said spherical aberration correcting electrode pattern according to said recording medium used.

59. The optical apparatus according to claim 58, wherein said coma aberration correcting electrode pattern is used for a DVD.

60. The optical apparatus according to claim 58, wherein said spherical aberration correcting electrode pattern is used for a CD.

61. The optical apparatus according to claim 58, wherein said objective lens is an objective lens for said DVD.